WOOD AND MAN

BY ADALBERT EBNER

In times of tension and worry there is nothing better for regaining one's repose than the sight of the starry night sky, the eternally moving sea, or Nature in her constant procreation. In our days of struggle for the fate of continents and peoples, it is comforting to turn away for once from politics and regard one of the greatest gifts of creation for mankind—the forest.

Like all true foresters, the author, a professor of forestry at the University of Munich, is a philosopher. For him, who knows not only the forests of his Bavarian home but has for years studied forestry in other parts of the world and taught it at foreign universities, where he has acquired an international reputation, the forest is far more than simply a botanical or economic phenomenon. In his eyes, the forester is a man who has assumed responsibility toward his people and the guardianship for one of the greatest of treasures. For him, the tree and the forest are not things that have been placed ready-made into the hands of Man. Instead, they appear to him in the process of growth and decay and in the great relationship of all life.

It is one of the aims of our magazine to present the world in its process of development and change, in politics as well as in other spheres of life. For that reason we have asked Dr. Ebner, who is at present in Japan, to write the following article for us.—K.M.

FROM the free play of forces, Nature obtains the material for her treasures. They grow forth under the light of the sun, born from the womb of the earth. Man had only to take them, even at a time when he himself was but part of the fauna.

Wherever chimneys belch forth smoke, from the forges of armies, from the workshops of peace, from chemical plants, their fires are fed with the remainders of a forest-like plant family—the carbonized shave-grass and ferns of past eons. A one-foot layer of coal is the product of a twentyfold thickness of closely packed, decaying organic substance. Some coal deposits are 8,000 feet thick. From this we can form an idea of the abundance of vegetation that once covered the earth and has formed a treasure reaching into our times.

And this process has not stopped: the youngest relative of coal, peat, is still being formed by decaying remainders of present-day moorland vegetation.

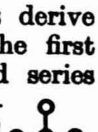
The process of carbonization calls our attention to the element of carbon, which originates from vegetable matter. Its nature is of special interest to us, for, beside water, it is the most important element of life.

THE ELEMENT OF CARBON

Organic chemistry teaches us that carbon is distinguished from all other elements in that it possesses the ability to form molecules in which carbon atoms can be combined—one carbon atom with another—in almost unlimited number. For this reason, it forms a constituent of all organic compounds.

In completely dry wood, carbon makes up 49.9 per cent of the weight, the rest being oxygen, hydrogen, and nitrogen. Since the carbon element is able to form an incredible variety of substances, wood and coal have become the most important raw materials of synthetic chemistry. To give a few examples:

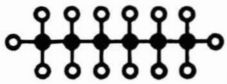
All organic carbon compounds derive from the dangerous methane, the first link in the practically unlimited series of hydrocarbons. Methane consists of one part of carbon (C) and four parts of hydrogen (H):



By a slight change we obtain ethane :

Replacing one hydrogen atom by an OH atom, we have alcohol :

Countless new combinations can thus be formed, for instance hexane :



Among the hydrocarbons are dextrose, glucose, cane sugar. From these again derive the polysaccharides, starch, and cellulose. Through the addition of the nitrate group there develop the protein substances. The possibilities are enormous.

THE MIRACLE OF ASSIMILATION

As a rule, we regard with awe the processes in chemical retorts, processes which spring from the human mind. Much less regard is generally paid to the processes taking place in the tree and its green leaves.

This natural process is called assimilation. By assimilation we mean the formation of complicated carbon compounds from the carbon-dioxide content of the air while oxygen is given off. In this process there are five functional quantities which play a basic role: light, the green coloring matter of the leaves known as chlorophyll, the carbon dioxide of the air, temperature, and the water content of the leaves. These five quantities must be in a perfect reciprocal relationship in order to allow assimilation. The production of matter takes place in the leaves, which, by evaporation and by making use of the capillary channels in the wood, suck up water through the roots. With the water, the tree receives the necessary minerals for its growth.

The products of assimilation are then turned by the tree, according to its requirements, into the various substances for growth, maintenance, and reserves. Thus the vegetable organism can build up the most peculiar compounds from just a few constituents. This is an ability that only plants seem to possess. Animals absorb the substances which can form complicated compounds through feeding on plants, a fact which links flora and fauna even more closely and lets them appear as a miraculous unity of Nature.

THE BORDER LINE BETWEEN LIFE AND DEATH

Vital assimilation is by no means exhausted in chemical reactions. A short comparison is enough to prove this.

In every chemical process outside of the living organism, the combination of two bodies results in the creation of a third and different body :

Living substance, however, through morphological assimilation creates a substance identical with itself :

As soon as enough matter has been assimilated, the living particle splits up actively :

Each of the new particles has the power to grow to the original size and then to undergo the splitting-up process again. Thus we see a single cell growing into a mighty multitude.

Life means that the individual particles of matter lose their individual lives for themselves and are lifted into the vital circulation. The function of each particle is determined by the living body, and the particles, by their submission to this directing force, make it possible for the whole to be a living organism.

Death appears as the moment when each particle becomes independent and leaves the vital circulation.

WHAT IS A FOREST?

As a rule, only especially tall forms of plants are called trees. Science has established five meters as the lowest limit for fully developed plants to be called trees. Within the category of "tree," there is a vast variety of forms. The tallest trees, the eucalypti, grow to a height of 500 feet; and the sequoias in California, with their trunks measuring 40 to 55 feet across and growing to a height of 350 feet, are, beside the cypresses in Mexico, the oldest living things on earth and look back on four to six thousand years of age.

The forest is one of the plant formations of which the will of the Creator has composed the earth's vegetation. The languages of all peoples have, since ancient times, had certain names for the various parts of this vegetation. When we use these words, we have an immediate impression; for instance, when we speak of desert, prairie, meadow, field, moor, heath, bush, or forest.

When many trees come together and cover so great a surface that they influence humidity, light, and temperature, and form a new climate; when they have entered a sociological community which in itself contains the power of renewal, then we have before our eyes the forest. A certain density per acre as well as competition are essential. Otherwise we have the transitional type between forest and prairie, the bush prairie, or Man's artificial creation, the park. All types of vegetation form communities; the forest, however, is the mightiest of all plant communities. Struggle and mutual aid are its strong driving forces. Stubborn in its never-ending struggle for space and light, it constantly advances and penetrates wherever it enters into competition with other plant communities in the free play of forces.

Besides the trees, there are innumerable animals and other plants, habitually living in the forest, which belong to the forest's community of life. Another vital component is the soil of the forest, so rich in living organisms. One ounce of soil contains about 30 million microorganisms, among which there are algae, fungi, and bacteria. The bacteria are among the most amazing phenomena in the plant world. They encourage life, but they also cause disease, plague, and death. They break up chemical and atomic compounds and provide for new and different ones. They cause the decomposition of decaying matter and see to it that the world does not suffocate in refuse. They extract nitrogen from the air and pass it on in an absorbable form. In one acre of forest there live up to one million animals; most of these are insects. Of course, the quantity of life is determined by climate and location and changes according to circumstances.

THE FOREST AS A BIOLOGICAL COMMUNITY

A rock decomposes and forms earth. Out of the fertile earth grow trees, let us say oaks. The oaks reach maturity, and acorns develop on their branches. These acorns nourish squirrels, which again are hunted by martens. Eventually these martens die, and the organic matter of their bodies decomposes. That which grew from earth, becomes earth once more. A series has been formed which we call the chain of food. Within this circle there is no closed circulation, for at every link some energy is lost. Some of the oaks perish early and immediately turn to earth again. Not all acorns are eaten, so that there is another part of energy lost which never reaches the squirrels, which, in turn, are not all eaten by the martens.

Rock → Earth → Oak → Acorn → Squirrel → Marten

The quantities of energy are split up in all directions. Squirrels biting the acorns drop particles of the fruit which serve to nourish a species of bird. These birds again are eaten by owls. The owl nourishes parasites. Thus our stream of energy flows apart like the branches and twigs of a tree. Since the animals in a forest live also off other plants, each plant becomes the crossroads of other chains of food. The whole system is interlaced.

Within itself, the biological community must undergo a constant process of compensation in order to ensure a state of balance. Otherwise individual participants in the community would disappear. Certain communities have remained stable for more than two hundred centuries. So ingenious a directing of forces and energies is revealed by this that the skill of Homo sapiens in his civilizations pales in comparison.

This equilibrium cannot be explained; one can only presume the existence of conditions which share in this directing. The state of balance requires, not only a constancy in the various links within a chain of energy, but also a constancy in the number of units making up an individual link. A larger number of animals of prey in a forest would have exterminated either their own prey or themselves; a smaller number would have fallen victim to the cold of winter, to disease, or other influences. The process of adapting within a community requires, not only certain attributes in order to remain alive, but also that number of units which has the peculiarity of being able to maintain itself. If the stream of energy is altered at any given place, it would cause these vital numbers and the reciprocal dependency of many participants to be changed at many points. Equilibrium and variety belong together in Nature. They were created together; one cannot exist without the other.

THE FORESTS OF THE EARTH

The name of "forest" is given to very different things. Forests differ from each other in their structure, their appearance, and, one might almost say, their inner nature. What causes these differences, what is there behind them? The answer can be found if we seek in three directions: we must consider the location of the forest, regard its appearance in the course of time, and, finally, explore the relationship between Man and forest, not only outwardly, but penetrating to the innermost depths.

First of all, we must understand the location of the forest in space. The forest does not grow by chance or by its own whim: it depends on geography. It grows and shapes itself according to its location and its distance from the sea. It is a child of light, sun, wind, and water. The power of the soil with its changing chemical composition, its varying physical structure, and its variable moisture content, models it into structures of vast differences. Especially striking is the relationship between the northern limit of forests and the 10° centigrade July isotherm.

The combination of various climatic components results in a climatic zone. As a substitute for series of climatic figures, one can very well use the relationship between climate and plant community and indicate the climate by a name for which a certain plant community stands godfather. Thus we speak of a birch climate, a prairie climate, a palm climate. These differences are especially apparent when we think of the tropical forest, which, with its five to six thousand different kinds of plants, all evergreen, is a picture of fertility. Compared with it, the northern conifer forest looks monotonous, and, at the borders of vegetation, even wretched.

We can also understand the differences between forests if we regard time in its course. In prehistoric times it was Nature herself who took a hand at changing the shape of species and form. Then came Man, and from the relationship between Man and Nature there developed what we call economies. The artificial forest was created. Blunders and reparation, all hope and faith, become alive in this relationship between Man and Nature. We can measure all the tensions and forces deriving from the economic, political, and spiritual manifestations of various periods and expressed in the constantly changing appearance of the forest.

With this we have already named the relationship between Man and forest as the third shaping force. Even outwardly it is striking in Man's material interference in the forest. But it is only its ethical effects which give us the key to a true and profound understanding of the theme "forest." It is above all a question of seeing those inner forces which lead to outward deeds and by which those deeds can be understood. The face of the artificial forest reflects the spiritual and mental powers of a people.

THE VARIOUS KINDS OF FOREST

In the schematic classification of the forests of the earth, a difference is made between forests proper and border forests, as they are called. The forests proper live in surroundings more or less favorable for them. The border forests have to struggle against adverse surroundings.

Forests Proper

(Forests in favorable surroundings)

In the northern boreal snow zone:
- Belt of Conifers
- Summergreen Hardwoods (i.e., green only in summer)

In the subtropics and tropics:
- Evergreen Laurel and Hardleaf Forests
- Tropical Rain Forests
- Raingreen Forests (i.e., green only after rain, also called Monsoon Forests) of tropical regions with seasonal change

Border Forests

(Forests struggling against unfavorable surroundings)

Dwarfed forests on the cold-temperature timberline:
- Polar Timberline
- Alpine Timberline

Forests on the arid timberline:
- Prairie Forests or Forest Prairies
- Savannahs
- Thorn Forests
- Gallery Forests
- Oasis Forests

Forests in regions of extreme oceanic influence:
- Heath Forests
- Moor Forests

Forests in the sphere of influence of water:
- Mangrove Forests on tropical coasts
- Meadow Forests in the flood areas of rivers
- Swamp Forests in marsh areas

From the womb of these forests springs the economic wealth of the peoples; in it germinate the cells of cultural happiness.

SOME FOREST STATISTICS

The surface of the earth covers approximately 510 million square kilometers. Of these, 149 million sq.km. (29.2 per cent) are land (including the antarctic continent), and 361 million sq.km. (70.8 per cent) are water.

The land surface of the earth is distributed as follows:

Desert, waste land, prairies, lakes and rivers	58.2%
Forest	22.1%
Arable land	19.7%

The forest surface is distributed among the various continents as follows (1 hectare=2.471 acres):

TABLE I

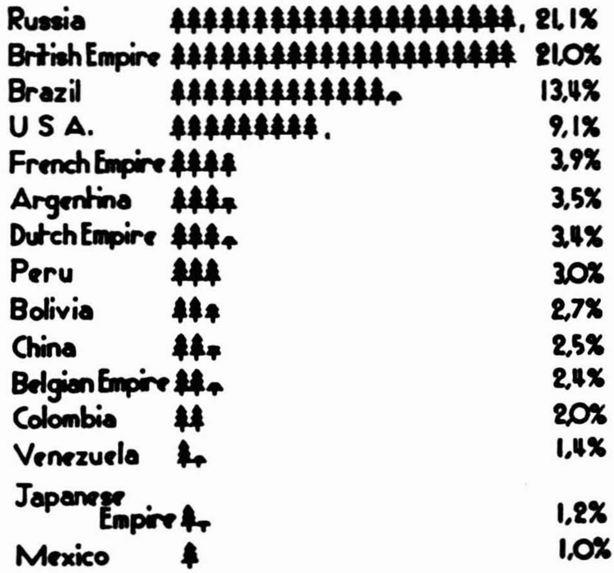
Continent	Forest Area (in mill. hect.)	Percentage of World Forest Surface	Percentage of Forest Land in Surface of Continent
Asia	848,251	28.0	21.6
South America ..	847,037	28.0	44.0
North America ..	584,387	19.3	26.8
Africa	322,545	10.6	10.7
Europe	313,238	10.3	31.3
Australia and Oceania ..	114,530	3.8	15.1

If we combine the innumerable types of forest of the earth into three basic forms, namely, conifer forests, temperate deciduous forests, and tropical deciduous forests, we arrive at the following distribution:

TABLE II

Continent	Conifer		Hardwoods of the Temperate Zone		Hardwoods of the Tropical Zone	
	mill. hect.	%	mill. hect.	%	mill. hect.	%
Europe	231,321	21.9	78,917	16.2	—	—
Asia	359,778	33.6	231,488	47.5	256,985	17.5
Australia and Oceania....	6,071	0.6	6,071	1.2	102,389	7.0
Africa	2,833	0.3	6,890	1.4	312,833	21.2
North America	423,316	39.5	117,363	24.1	43,708	3.0
South America	44,112	4.1	46,541	9.6	756,384	51.3
Total	1,070,431	100.0	487,260	100.0	1,472,299	100.0

Roughly speaking, 35.4 per cent of the earth's forests are coniferous and 64.6 per cent deciduous. Of the deciduous forests, 48.6 per cent grow in the tropics. The following chart shows the distribution of the total forest surface of the earth among the various countries, according to the figures for 1936. (Owing to the world crisis, no reliable statistical data are available after that year.)



In 1936, Germany possessed no more than 0.4 per cent of the forests of the earth. England, France, Belgium, and the Netherlands had in their mother countries together not more than 0.4 per cent of the forest surface of the earth. As a result of their extensive colonial possessions, however, they controlled 30 per cent. Together, Russia, the British Empire, Brazil, and the United States possessed 64.4 per cent of the forests of the earth.

The annual cut of wood (consumption) in cubic meters (1 cubic meter=35.32 cubic feet) is as follows:

TABLE III

Continent	Firewood	Timber	Total
Europe	222,070,326	259,372,082	481,442,408
Asia	184,478,746	47,010,288	231,489,234
North and Central America ..	363,021,093	424,317,689	787,338,782
South America	63,223,430	7,322,401	70,545,831
Africa	18,544,144	1,768,272	20,312,416
Australia and Oceania ..	5,151,830	2,625,961	7,777,791
Total ..	856,489,569	742,416,893	1,598,906,462

TABLE IV

CONSUMPTION OF TYPES OF WOOD

(in cubic meters)

Types of Wood	Total Yield
Coniferous Wood	788,687,345
Hardwood of the Temperate Zone	668,744,116
Hardwood of the Tropics....	141,575,000
Total	1,599,006,461

The main burden of wood consumption is at present being borne by the northern conifer forest belt, which, with a 35.4 per cent share in the total surface, has to provide about 50 per cent of the total requirements. If one adds to this the supply of hardwood from the temperate zone, there remains only about 6 per cent of the world's consumption which must be covered by the vast complex of the tropical forest. Considering the advanced shrinkage in the temperate zone's supply of wood, the tropical forest reserves will in future have to play a far greater part than hitherto.

TABLE V

Shares of 18 Countries which in 1936 Supplied Approximately 90 per cent of the World's Commercial Timber

Country	(in mill. cub. m.)	Percentage of Total World Production	
		Timber	Firewood etc.
USA	688,055	52.6	43.2
Russia	205,274	17.4	14.2
Canada	70,768	4.2	4.2
Japan	72,362	1.5	4.0
China	55,855	1.1	3.5
India	44,519	0.7	2.8
Sweden	44,308	4.6	2.8
Finland	37,281	3.4	2.3
Brazil	36,810	0.4	2.3
Germany	33,247	2.3	2.1
France	25,200	1.2	1.7
Yugoslavia ..	22,189	1.1	1.4
Mexico	19,820	0.2	1.2
Chile	19,368	0.2	1.2
Poland	18,900	1.2	1.2
Czechoslovakia	15,992	1.3	1.0
Italy	13,005	0.3	0.8
Norway	12,232	1.1	0.8

OUTSTANDING EXAMPLES OF FORESTRY

The search for the most useful tree reveals many interesting facts. Naturally there are many kinds of trees which, in their particular surroundings, can be classified as extremely valuable. Seen objectively, however, the palm tree deserves first place. It supplies food—drink — clothing — fuel — wood — roofs—nets—rope and string—rigging—oils—butter — vinegar — alcohols — wines — articles of daily use—household utensils—eating utensils—ships—hats and shoes—brushes and combs—medicines—illumination—carpets—mattresses and covers—sails—sugar and syrup—dyes—and many other things. No other tree has so much to give. The palm tree is the symbol of eternal summer, of endless growth in the ever-fertile south. It is the best known of all tropical trees, and it can resist tropical storms because it has a leaf that offers little resistance and turns elastically before the wind, because it has a root with elastic fibers, because its wood is strong and resistant, and because it possesses, in spite of its frugal requirements, a mighty will to live and rises up again and grows toward the sky even after it has lain flat on the ground.

Among the approximately one thousand varieties of palm trees, the coconut palm is the most important. In 1926, 1.5 million tons of coconut-palm products were sold in the world markets. Two thirds of these were copra. Within the last thirty years, the export of these products from the southern zones has increased tenfold.

One of the most important forest products for the twentieth century is wood fiber. Almost everyone knows that it is made into paper. Modern chemistry dissolves it and spins it into rayon, turns it into staple fiber and artificial wool, or uses it as the basis for an abundance of modern materials. To cover the paper requirements for a normal daily edition of the *New York Times*, the entire wood of a hundred acres of forest with a good stand of timber is needed. The annual requirements of newsprint paper in North America would suffice to girdle the globe with a paper band forty-seven miles wide.

The wood production of America has long passed its peak. Nevertheless, its annual yield of timber would be enough to pave a road from the earth to the moon, twenty-three feet wide and one inch high.

Drugs and poisons form another valuable group of products supplied by trees and plants. It is a peculiar fact that many plants contain drugs which, according to their application, can cause either cure or destruction. In olden times only medicines made from plants were known. Even some of the most important standard medicines of modern times can be traced to a plant origin. The Indians of South America had great knowledge in their application thousands of years ago. In 1638 the wife of the Viceroy of Peru was cured of malaria by an infusion made from a bark. That founded the world-wide reputation of quinine, made from the bark of the cinchona tree. For the last fifty years, the cinchona plantations in Java have been supplying ninety-nine per cent of the world's requirements. The leaves of the coca shrub produce cocaine, indispensable in modern surgery for local anesthetics and the alleviation of pain. An acacia tree in Africa excretes a substance which causes blindness, while, on the other hand, the belladonna plant gives us a juice which alleviates and aids in the cure of many eye diseases.

The world is in the midst of a conflict for some of the most important raw materials, such as vegetable fats, oils, rubber, terpene, tannin, dyes, and lacquers, all of which are produced from the sap and other parts of trees and forests. While in 1900 the production of rubber was no more than 54,000 tons, half of which was supplied by Brazil, by 1939 it had risen to more than a million tons, originating mainly from the plantations of Greater East Asia.

At one time, forests directed the streams of the great migration of peoples; they limited the expansion of conquerors and thus influenced history. The German Army has established its own army forest administration and has in this way proclaimed the importance it attaches to forests and wood for the army in peace and war.

WOOD—ONE OF THE WORLD'S RAW MATERIALS

Since ancient times, wood has supplied a material easy to work and available in abundance. Wherever settlers began to cultivate the land, the success of their labors stood and fell by the raw material of wood. The plough of prehistoric times, still to be seen in museums, had a wooden share made from a gnarled log. Petrified remains, four to six thousand years old, from lake dwellings in southern Germany, point to the importance of wood for the civilization of earliest times. As we know from excavations, the Romans had large parts of their great military roads towards the north of Germany built of wood. The power of the *Imperium* throbbed along these highways. Masterpieces from the Middle Ages proudly testify to the durability, quality, and beauty of a material which brought fame to European arts and crafts and encouraged creative work throughout the world. Wherever we look, we find wood used as a raw material. All through his life, Man is reminded daily of wood by the cradle, the table, the bed, and the coffin.

A short survey of the uses found for wood indicates, at least in rough outline, the multiplicity of goods which are manufactured from it; it shows how essential a part in the growth and execution of national economies is taken by this raw material from the forests. The use of wood can be divided into two large groups: the mechanical-technological use while maintaining its natural structure, and the transformation of its elemental components into other products by means of chemical processes.

Wood is an indispensable material for the construction of buildings, earthworks, mines, irrigation systems, and bridges. Split up, it is manufactured into barrels and tubs, into shingles and panels. The interior construction of houses is dependent on wood. In the workshops of turners, carpenters, joiners, wagonmakers, woodcarvers, millmakers, and instrumentmakers, wood is turned into things useful, indispensable, or attractive for daily life. In modelmaking-, machine-, and workshops, wood has become indispensable. Large quantities of wood are used in agricultural and similar establishments. Chemistry and engineering have studied the attributes of wood. Through new treatments (veneering and gluing), repairing of flaws, and the addition of qualities hitherto unknown, but still using wood in its natural structure as the basic material, undreamed of products of the highest quality have been created, possessing high-pressure resistance, absolute dryness, fire resistance, and immunity against fungi and other influences. These new materials fulfill the highest possible standards for the construction of airplanes, machinery, and other equipment.

The chemical exploitation of wood went hand in hand with the general progress of chemistry. The first metamorphosis was achieved with the first fire in which wood was burnt. The charcoal process already entailed great expansion. Although paper was first manufactured as early as 105 B.C.—paper was at that time made from the inner bark of the mulberry tree—the great paper industry as well as the manufacture of pulp and cellulose are achievements of modern chemistry and engineering. About the middle of the last century, the Munich scientist Pettenkofer discovered the production of gas from wood for purposes of lighting and power. Twenty-two pounds of wood correspond to the energy of a gallon of gasoline.

Through the process of wood hydrolysis, two thirds of the wood can be transformed into raw wood sugar. By means of the appropriate processes of fermentation, alcohol, yeast, glycerin, furfural, resins, acetic acid, and many other valuable products can be obtained from this wood sugar. A hundred pounds of lignin ferments into four gallons of alcohol. All elements of human nourishment can be obtained from wood. It has been calculated that one acre of forest soil produces the same amount of fodder as one acre of average arable land.

Parallel with the elements of human nourishment, the elements of human clothing are being obtained from wood by modern processes. Today everyone is acquainted with rayon, staple fiber, and artificial wool. (The latter is mainly a finely cut, spun rayon thread.) The production of rayon, spun from threads 0.004 of an inch thick, was discovered by the German scientists Pauly and Brennert.

When we speak of wood as a basic material for modern use, we mean by that the improvement and transformation of its fundamental characteristics to suit our high demands. Thus a building and working material has arisen whose form, quality, and durability have been improved to such a degree that they fully satisfy the demands for a good working material. "Chemical wood" forms the basic product for fuel for furnaces and motors, for cellulose and fibers, as well as for food and fodder. In this sense, wood is also a basis for synthetic materials from which cellulose, hydrate cellulose, nitrocellulose, primary acetylcellulose, and secondary acetylcellulose are made, resulting in providing further new working materials, substitutes, and many other cellulose derivatives.

More impressive, perhaps, than the fact that wood forms the basic material for some four to five thousand different products, is the thought that the most important human requirements—housing, utensils, clothing, food, as well as energy in the form of heating and power—are filled by wood.

Wood is the green gold and the evergrowing raw material of a nation. But this does not by any means exhaust the value of forests.

The organic situation of a forest within a given space makes it a twofold guarantor of well-being. With regard to ground culture, the forest conserves the soil, mildens the climate locally, and wards off many harmful influences of Nature. The characteristic of this protective forest is the negative warding off of dangers.

With regard to human culture, the positive side of its effect on well-being points toward ethical and hygienic relations. From the close association of forest and people, there develop germ cells of culture and the sources of happiness. The recognition of this fact raises the noneconomic gifts of the forest to highest appreciation. As the German writer W. H. Riehl has so admirably put it: "A people must die out if it cannot turn to its forest-dwellers, to obtain from them renewed natural strength. We must preserve the forest, not only so that our stoves do not grow cold in winter, but also so that the pulse of the people's life shall go on beating warmly and happily."